International Journal of Infectious Diseases (2009) **13**, 629—635


http://intl.elsevierhealth.com/journals/ijid

# Food-related norovirus outbreak among people attending two barbeques: epidemiological, virological, and environmental investigation

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Received 11 April 2008; received in revised form 2 September 2008; accepted 11 September 2008
**Corresponding Editor:** William Cameron, Ottawa, Canada

**KEYWORDS**
Norovirus;
Outbreak;
Food-borne;
Viral gastroenteritis;
Cohort study;
Case—control study

**Summary**
*Background:* Norovirus (NoV) is commonly associated with gastrointestinal infection. It is normally transmitted person-to-person or from contaminated surfaces, although food-borne transmission is possible.
*Methods:* We conducted environmental, epidemiological, and microbiological investigations to ascertain the route of transmission of two linked outbreaks of NoV associated with events where food was consumed. Multivariate logistic regression was used to determine food items independently associated with infection.
*Results:* In outbreak A, 19 of the 26 people who completed the food questionnaire fulfilled the case definition. The highest relative risks (RR) were for chicken kebab (RR 3, 95% confidence interval (CI) 0.9—10.4), pork sausages (RR 2.1, 95% CI 0.5—9.1), pasta salad (RR 1.94, 95% CI 0.9—4.1), cheese (RR 1.6, 95% CI 0.9—2.8), and green leaf salad (RR 1.5, 95% CI 0.9—2.4). In outbreak B, 60 of the 106 people surveyed fulfilled the case definition. Green leaf salad (adjusted odds ratio (aOR) 3.2, 95% CI 1.4—9.9) and coleslaw (aOR 8.2, 95% CI 3—22.2) were independently associated with illness in the multivariate logistic regression model. NoV genogroup II genotype 6 (GII-6) was identified in cases of both outbreaks and a food handler who had prepared salads for both events.
*Conclusion:* Because outbreak investigations of small cohorts may not yield epidemiological association to food, most of these outbreaks may be attributed to the person-to-person transmission route. Therefore ascertainment of food-borne NoV infection may be low, underestimating the true prevalence of this route of transmission.


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1201-9712/$36.00 
doi:10.1016/j.ijid.2008.09.023

## Introduction

Norovirus (NoV) is a small round structured virus of the *Caliciviridae* family. It causes gastrointestinal symptoms in humans. It transmits person-to-person by the fecal–oral route and via environmental contamination.[1] Food-borne outbreaks have also been described in the literature, mainly associated with shellfish, frozen berries, and salads.[2–7] Because of the lack of long-lasting immunity in those affected and the small infective dose required, NoV outbreaks tend to affect large numbers of people.[8,9]

In England and Wales, most recorded outbreaks of NoV have occurred in healthcare settings (i.e., hospitals and care homes).[8] In this setting the greatest peak occurs in the winter, although infection occurs all year round.[10] There is probably under-reporting of outbreaks in other settings.

NoV outbreaks in Norfolk are reported to the Health Protection Unit (HPU) throughout the year with a peak in the winter months. The majority of cases occur in residential and nursing homes, and hospitals. More rarely outbreaks have been reported in schools and food outlets.

There is no formal surveillance system for NoV infections in Norfolk (East of England). In England suspected outbreaks of gastrointestinal infections are reported by institutions or members of the public to local authorities as well as the HPU. As part of the investigations into gastrointestinal infection outbreaks, fecal samples are tested for NoV. Positive samples are sent to the Health Protection Agency Reference Laboratory for further characterization. National surveillance of NoV strains associated with outbreaks of gastroenteritis involves characterization of strains collected at the beginning, middle, and end of each NoV season throughout the regions of the UK, including the East of England.[11]

In August 2007 the Norfolk team of the Norfolk, Suffolk and Cambridgeshire HPU was notified by South Norfolk District Council (SNDC) Environmental Health Department (EHD) of a number of cases of gastroenteritis in people who had attended a barbeque 2 days earlier, reported by the organizer of the event. An outbreak control team (OCT) was arranged at short notice and investigations and control measures instituted. The following day, the HPU was notified by North Norfolk District Council (NNDC) EHD of a second outbreak of gastroenteritis following a barbeque that occurred on the same day as the other outbreak, also reported by the organizer of the event. It later became evident that food served at both events was provided and prepared by the same catering company. The OCT investigated and instituted control measures for both outbreaks.

Investigations were aimed at ascertaining the causal organism of the outbreak and the source of the infections. The control measures were intended to minimize further spread and the risk to other members of the public. Here we present and discuss the investigations and control measures.

## Methods

### Environmental investigation

The Environmental Health Officers (EHOs) from two local authorities visited the venues where the two events took place to assess facilities, collect guest lists, ascertain seating arrangements, and to enquire about episodes of vomiting or suspected diarrhea during the events. Subsequently, the caterer's premises were inspected and food preparation procedures were discussed. Storage and preparation of food were investigated during the visit. Samples of food items left over from the two events or at the caterer's premises were also collected.

### Epidemiological investigation

A case was defined as any person who had attended either of the barbeques and who had developed symptoms of nausea, vomiting, diarrhea, or malaise. Two epidemiological studies were conducted. Standard food questionnaires were sent by mail within a week of the initial report to the HPU, to those people identified as having attended either of the barbeques. The questionnaire asked about age, sex, symptoms and date/time of onset, and consumption of food items at the events. These enabled estimation of the attack rate, incubation period, and nature and duration of symptoms.

All of those who attended barbeque A could be identified. Hence, outbreak A was studied as a retrospective cohort, calculating attack rates and relative risks (RR) for individual food items. In the case of outbreak B, it is estimated that over 200 people attended but only a proportion could be identified; for this reason outbreak B was analyzed as an unmatched case–control study, where cases were those who completed the questionnaire and reported symptoms as per the case definition. In this case we calculated odds ratios (OR) for individual food items, and adjusted these by introducing those variables that were statistically significant ($p < 0.05$) into a multivariate logistic regression model to determine those food items independently associated with illness. All data were analyzed using SPSS v. 14.0. We did not ask for secondary cases outside those who attended the events.

### Microbiological investigation

Fecal specimens obtained within 48 hours of onset of symptoms were cultured in the local microbiology laboratory for 48 hours in a range of media to allow detection of bacterial and viral enteric pathogens, in accordance with the National Standard Methods for investigating outbreaks of gastroenteritis (VSOP3, http://www.hpa-standardmethods.org.uk/pdf_sops.asp). In addition, samples were also tested in the IDEIA™ Norovirus EIA kit, which utilizes a combination of both genogroup 1- and genogroup 2-specific monoclonal and polyclonal antibodies in a solid-phase immunoassay for rapid detection of NoV genotypes.[12] Reactive specimens and specimens of exceptional importance in the outbreak collected later than 2 days after onset of symptoms were sent to the HPA Centre for Infections for NoV PCR to enable specific genotyping.[11] Genotyping was performed using GIIFBN/GIISKR primers, as previously described.[11] Genotyping was performed on five samples from the outbreaks A and B (A-1 and B-1, B-2, B-3, and B-4) and one sample from the food handler (FH).

Samples from leftover food were stored frozen while the epidemiological and environmental investigations were conducted, and later sent out for processing. PCR specific for

NoV genogroup II[13] was carried out by the HPA Environmental Virology Unit (Reading) on a portion of the concentrate obtained from 25 g of the above samples.

Demonstration of a transmission event was investigated by sequencing the gene encoding the P2 (protruding) domain region of the NoV capsid, as previously described.[14] Specific primers for GII-6 genotypes were used to amplify the P2 domain from cDNA previously used for genotyping. A hemi-nested PCR assay was developed to generate PCR amplicons suitable for sequencing. The first round assay used primers P2 GII-6F/P2 GII-6R,[14] the second round assay (hemi-nested) used primers P2 GII-6FN (5′ CAC CAA CTG TTG AAT CAA AAA 3′, this study)/P2 GII-6R. The hemi-nested PCR mix included 4.5 μl 10X buffer (Invitrogen, Paisley, UK), 2.5 μl 50 mM $MgCl_2$ (Invitrogen), 1 μl dNTPs (Invitrogen), 20 pmol of each primer, 5 units Taq polymerase (Invitrogen), RNase-free water to 43 μl, and 2 μl of first round template; machine conditions were as previously described.[14]

DNA was purified using a commercially available PCR product purification kit (Agencourt® AMPure®, Beckman Coulter, High Wycombe, UK) and was sequenced in both directions using NoV P2 GII-6FN and P2 GII-6R primers and a CEQ Dye Terminator Cycle Sequencing Quick Start kit (according to the manufacturer's instructions (Beckman Coulter)) and a Beckman Coulter CEQ8000 capillary sequencer. Generation of consensus sequences and pairwise alignments of the inter-primer region (P2 GII-6FN/P2 GII-6R) of sequences was performed initially using Genebuilder and Clustal in Bionumerics v. 3.5 (Applied Maths, Kortrijk, Belgium). Sequence analysis was performed using the 492-bp region of the P2 domain region of NoV strains from this study and compared to other UK outbreak strains (Figure 1). GII-6 strains from outbreaks occurring in 2006 in West Wales and in 2007 in the Northwest of England were selected for comparison and were representatives of GII-6 outbreaks from the recent past.

## Results

One catering company supplied the food served at both events, which consisted of a selection of barbequed meats and salads. All food was prepared at the caterer's premises and transported to both venues. All meats to be consumed at the event were prepared in-house at the caterer's premises (e.g., kebabs, burgers, and sausages); they were partially cooked before transport and put onto the barbeque to complete the cooking once on site at the venues. One catering worker prepared all the salads for both of the events. Because both events took place simultaneously, four separate vans and catering teams were used. There was no cross-over of staff between the events.

### Environmental investigation

EHOs visited both venues and found that in both cases parties were outdoors with no specific seating arrangements, and there were no reported incidents of sickness during the functions. Samples of leftover salads, burgers, and sausages were collected from the venue of outbreak A. No leftovers were available from outbreak B.

EHOs also inspected the catering company premises. Burgers, sausages, kebabs, and salads were prepared on-site; however, salads were prepared in a separate room to meat products. The review of food preparation practices and facilities was unremarkable. The sausages and kebabs were cooked prior to the event and reheated on arrival. The steaks and burgers were cooked from raw. The caterer transported the raw and cooked food in four separate vehicles (two vehicles for each of the events catered for); none of the vehicles were refrigerated. The caterer covered the salads with a damp cloth during transportation. As a control measure to prevent further outbreaks of food poisoning, the caterer was advised on appropriate methods of food storage and refrigeration during transportation.

### Epidemiological investigation

Figure 2 shows the epidemic curve of both outbreaks. Twenty-eight people attended the barbeque at venue A; all were contacted and 26 (92.9%) completed the symptoms and food questionnaire. Of these, 19 (73.1%) had symptoms consistent with the case definition. The mean incubation period was 32 hours (range 15—55 hours). The most frequently reported symptoms were abdominal pain (89.5%) and nausea (84.2%), followed by diarrhea (52.6%), vomiting (57.9%), and fever (52.6%). Symptoms lasted on average 37 hours (range 24—72 hours). None of the cases required hospitalization (Table 1).

For outbreak A, none of the food items served had a statistically significant RR. The highest RRs were for chicken kebab (RR 3, 95% CI 0.9—10.4), pork sausages (RR 2.1, 95% CI 0.5—9.1), pasta salad (RR 1.94, 95% CI 0.9—4.1), cheese (RR

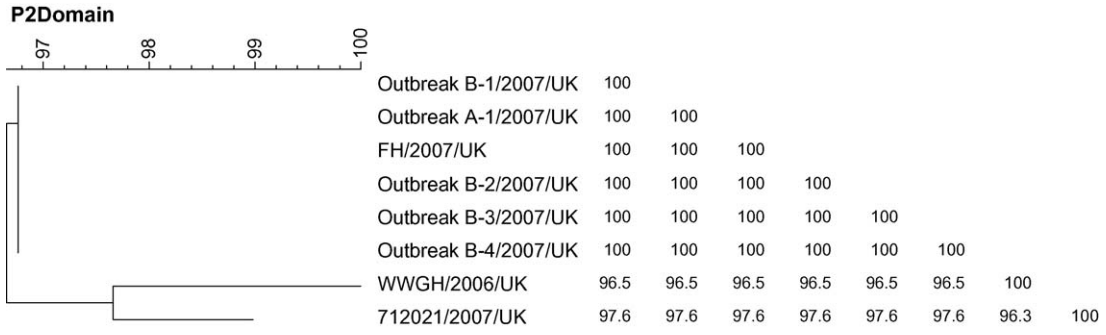


**Figure 1** Dendrogram of P2 domain sequences and similarity matrix of Norwich barbeque outbreak strains compared to other UK based outbreak strains.

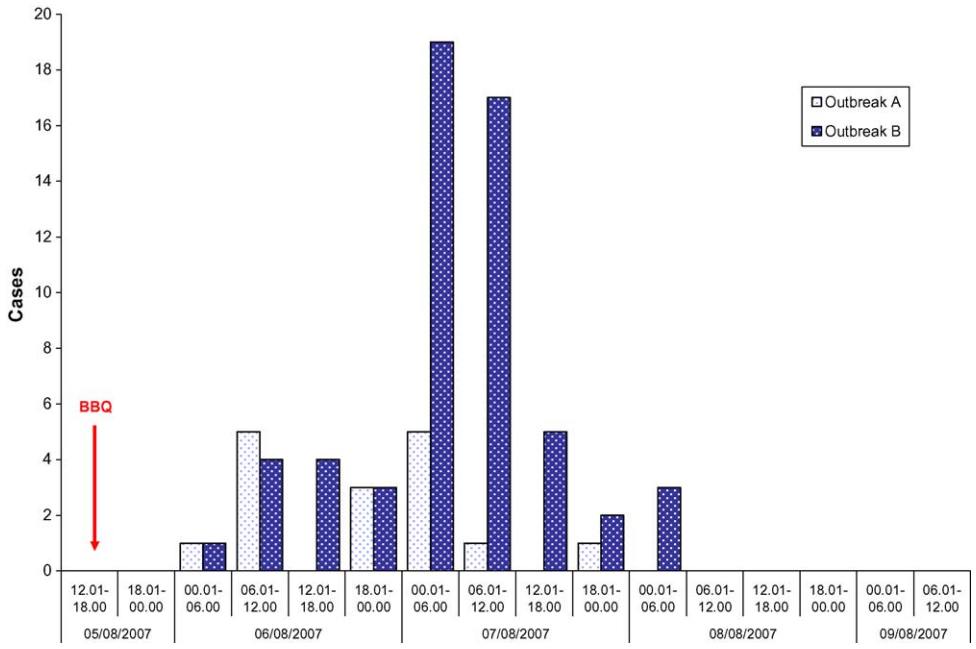


**Figure 2** Epidemic curve for outbreaks A and B, August 2007.

1.6, 95% CI 0.9—2.8), and green leaf salad (RR 1.5, 95% CI 0.9—2.4). The narrowest confidence interval was observed for green leaf salad and cheese (Table 2). Multivariate logistic regression did not yield any more significant results.

Over 200 people were invited to the barbeque at venue B, however, those who attended came in with guests and family. As a result it is difficult to be certain of the number of people who attended the party, although it is estimated that the attendance figure was around 250 people. We sent questionnaires to 194 guests, and 106 (54.6%) were completed and returned. For this outbreak we identified 60 people who fulfilled the case definition. The mean incubation period was 39 hours (range 11 to 64 hours). The most prominent symptoms were diarrhea (83.3%) and nausea (83.3%), followed by abdominal pain (78.3%), vomiting (75%), and fever (55%). Symptoms lasted on average 44 hours (range 1 to 120 hours). Again, none of the cases required hospitalization. Several food items had significantly elevated ORs on univariate analysis; however, green leaf salad (adjusted odds ratio (aOR) 3.7, 95% CI 1.4—9.9) and coleslaw (aOR 8.2, 95% CI 3—22.1) were independently associated with illness in the multivariate logistic regression model (Table 2).

Of the catering staff, none reported symptoms prior to the two events. The person who prepared the salads to be consumed at both events also reported symptoms of diarrhea soon after the events.

**Table 1** Demographic and clinical characteristics of the cases

| | Outbreak A $n = 19$ | Outbreak B $n = 60$ |
|---|---|---|
| Age, years; mean (range) | 38.5 (13—83) | 33.6 (15.5) |
| Gender (% female) | 10 (52.6%) | 33 (55%) |
| Clinical | | |
| Attack rate[a] | 19 (73.1%) | 60 (56.6%) |
| Onset of symptoms, hours; mean (range) | 32 (15—55) | 39 (10.5—63.5) |
| Duration of symptoms, hours; mean (range) | 37.3 (24—72) | 43.8 (1—120) |
| Symptoms | | |
| Diarrhea | 10 (52.6%) | 50 (83.3%) |
| Vomiting | 11 (57.9%) | 45 (75%) |
| Abdominal pain | 17 (89.5%) | 47 (78.3%) |
| Nausea | 16 (84.2%) | 50 (83.3%) |
| Fever | 10 (52.6%) | 33 (55%) |
| Blood in stool | Nil | 1 (1.7%) |
| Test and outcome | | |
| Specimen taken | 1 (5.3%) | 11 (18.3%) |
| Hospitalization | Nil | Nil |

[a] Outbreak A: $n = 26$; outbreak B: $n = 106$.

**Table 2** Epidemiological investigation of outbreaks A and B

| Food item | Outbreak A | | | Outbreak B | | | |
|---|---|---|---|---|---|---|---|
| | Attack rate, unexposed | Attack rate, exposed | RR (95% CI) | Control ($n$ = 46) | Case ($n$ = 60) | OR (95% CI) | aOR (95% CI) |
| Beef burger | 4/4 (100%) | 15/22 (68.2%) | | 26 (56.5%) | 39 (65%) | 1.43 (0.65–3.14) | |
| Chicken kebab | 4/8 (50%) | 15/18 (83.3%) | 3 (0.87–10.41) | 23 (50%) | 44 (73.3%) | 2.75 (1.22–6.20) | |
| Pork sausage | 9/14 (64.3%) | 10/12 (83.3%) | 2.14 (0.5–9.11) | 20 (43.5%) | 47 (78.3%) | 4.70 (2.02–10.96) | |
| Sirloin steak | 12/17 (70.6%) | 7/9 (77.8%) | 1.13 (0.63–2.02) | - | - | - | |
| Greek salad | 17/23 (73.9%) | 2/3 (66.7%) | 0.96 (0.68–1.35) | 5 (10.9%) | 25 (41.7%) | 5.86 (2.02–16.92) | |
| Green leaf salad | 11/17 (64.7%) | 8/9 (88.9%) | 1.48 (0.91–2.41) | 10 (21.7%) | 39 (65%) | 6.69 (2.78–16.10) | 3.70 (1.38–9.92) |
| Coleslaw | | | | 8 (17.4%) | 43 (71.7%) | 12.02 (4.67–30.97) | 8.18 (3.03–22.08) |
| Potato salad | 9/13 (69.2%) | 10/13 (76.9%) | 1.21 (0.54–2.68) | 11 (23.9%) | 37 (61.7%) | 5.12 (2.18–12.03) | |
| Mixed salad | 18/25 (72%) | 1/1 (100%) | 1.06 (0.95–1.17) | 6 (13.0%) | 17 (28.3%) | 2.64 (0.96–7.35) | |
| Pasta salad | 7/12 (58.3%) | 12/14 (85.7%) | 1.94 (0.91–4.11) | 2 (4.3%) | 8 (13.3%) | 3.39 (0.68–16.78) | |
| Ice cream | - | - | - | 24 (52.2%) | 44 (73.3%) | 2.52 (1.12–5.69) | |
| Bread roll | 2/2 (100%) | 17/24 (70.8%) | - | 26 (56.5%) | 44 (73.3%) | 2.12 (0.94–4.79) | |
| Butter | 17/24 (70.8%) | 2/2 (100%) | 1.12 (0.96–1.3) | 2 (4.3%) | 4 (6.7%) | 1.57 (0.28–8.98) | |
| Ice | 18/24 (75%) | 1/2 (50%) | 0.91 (0.66–1.25) | 1 (2.2%) | 3 (5%) | 2.37 (0.24–23.55) | |
| Ketchup | - | - | - | 8 (17.4%) | 22 (36.7%) | 2.75 (1.09–6.94) | |
| Mustard | - | - | - | 3 (6.5%) | 2 (3.3%) | 0.50 (0.08–3.09) | |
| Horseradish | - | - | - | - | 1 (1.7%) | - | |
| Mayonnaise | - | - | - | 2 (4.3%) | 14 (23.3%) | 6.70 (1.44–31.18) | |
| Balsamic vinegar | - | - | - | 1 (2.2%) | - | - | |
| Salt and pepper | - | - | - | 2 (4.3%) | 6 (10%) | 2.44 (0.47–12.72) | |
| Relish | - | - | - | 1 (2.2%) | 7 (11.7%) | 5.94 (0.70–50.14) | |
| Fried onion | - | - | - | 1 (2.2%) | 6 (10%) | 5 (0.58–43.08) | |
| Cheese | 10/16 (62.5%) | 9/10 (90%) | 1.63 (0.97–2.75) | 2 (4.3%) | 4 (6.7%) | 1.57 (0.28–8.98) | |
| Dessert | 10/14 (71.4%) | 9/12 (75%) | 1.09 (0.5–2.35) | - | - | - | |

RR, relative risk; CI, confidence interval; OR, odds ratio; aOR, adjusted odds ratio.

### Microbiological investigation

Microbiological investigations were arranged for human and food samples related to the outbreak. Fecal samples were obtained for one patient from outbreak A and 11 patients from outbreak B. Additionally one sample was obtained from a symptomatic food handler who had prepared salads for both events. The sample from outbreak A and a total of four samples from outbreak B were positive for NoV. In addition, the sample from the food handler was also positive for NoV. Three of the specimens, one from each outbreak and the food handler, were of genogroup II. All six specimens from outbreaks A and B and the food handler, genotyped as GII-6 (Seacroft/1990/UK) strains and had identical sequence over 282 bp of the 5′ end of the S (shell) domain of the capsid gene. Further analysis of 492 bp of the P2 domain of the capsid gene demonstrated 100% nucleotide sequence identity over this region (Figure 1). None of the samples was positive for other bacterial enteric pathogens.

Only the leftover salad samples from outbreak A were sent to the HPA Environmental Virology Unit, Reading for analysis. A prototype PCR assay used predominantly for the detection of NoV GII in sewage sludge was used in an effort to detect NoV in these salad samples. Despite repeat analysis and a positive internal control result, NoV was not detected in any of the salad samples analyzed.

## Discussion

In the outbreaks presented here, microbiological and epidemiological investigations are consistent with food-borne NoV infection. High aORs for coleslaw and green leaf salad in outbreak B point towards NoV contamination of salads. In addition, we were also able to detect NoV in a fecal sample from a food handler who had prepared the salads for both events. However, the food handler claimed that she had had no diarrhea and vomiting until later on that day. Moreover, we were also able to identify the same NoV genotype (GII-6) in both outbreaks and in the food handler who prepared the salads. As a result we can hypothesize that the food handler was infected with NoV and because of mild or no symptoms at the time, inadvertently contaminated the salads during the preparation process.

NoV can cause gastrointestinal infection. It is normally transmitted person-to-person and from contaminated surfaces associated with outbreaks.[1,15] However, there is evidence that food-borne transmission can occur, particularly from contaminated shellfish, frozen berries, and salads.[2–7] One recent study has also suggested that pigs may harbor human NoV and excrete this in their feces, resulting in contaminated pork meat that may be a source of infection for humans.[16]

Within the limited number of samples analyzed, it was possible to detect the presence of NoV and the genotype. The NoV strain was identical from the fecal specimens analyzed and genotyped as a GII-6 (Seacroft/1990/UK) in the S domain and all strains had identical sequence in the P2 domain, indicating that a transmission event was likely. We believe that the food handler who prepared the salads and who, although was feeling unwell on the day did not report symptoms of diarrhea until after both events, may have contaminated the salads. However, we were not able to identify NoV in any of the few leftover food samples tested. Environmental tests to detect NoV in foods are only available for the purpose of research and development and are only performed in specialized laboratories. A standardized assay is not yet available for the analysis of food items other than raw molluscan shellfish. The sample preparation procedures used are time-consuming and the low viral load in food makes analysis largely unsuccessful.[17] Furthermore, as meat products were not tested for NoV, we cannot exclude any cross-contamination from meat products and the salads during preparation.

NoV infection is common and widespread. Recent published reports have highlighted the importance of food-borne NoV infection;[2,18] however, we believe that ascertainment of food-borne NoV infection is relatively low. In outbreaks affecting small cohorts like in our outbreak A, it may be difficult to prove an epidemiological link to food or food preparation, and because the main transmission route of NoV is person-to-person, it is possible that a proportion of food-borne NoV outbreaks could be wrongly labeled as transmitted person-to-person, therefore underestimating the significance of the food-borne transmission route.

Guidance is clear that food handlers should be excluded from work if they have symptoms of diarrhea and vomiting.[19,20] In these outbreaks, the food handler who prepared the salads claimed that at the time she only felt mildly dizzy but had no nausea, diarrhea, or vomiting until later on that day. Because NoV infection may present with mild symptoms or as asymptomatic excretion,[21,22] we suggest that, in the catering business, food handlers preparing food that is to be consumed raw or not to be re-heated after handling should adhere to strict hand hygiene at all times to minimize contamination of food. Also, where practical they should be deployed to other tasks, to minimize the risk of contamination of foods, if they have had a recent contact with someone with gastrointestinal illness and are not feeling well, even if they do not have clear symptoms of gastrointestinal infections.

## Acknowledgements

We are grateful for the help of all the Environmental Health Officers who participated in the investigation and control of this outbreak: Sue Nixon, Chris Lynch and Judith Trohear (South Norfolk District Council); Tracy Wright and Gemma Williams (North Norfolk District Council); Chris Gooding (Norwich City Council). Also thanks to Sima Jalili and Catherine Tremlett (Microbiology Department, Norfolk and Norwich University Hospital) for their participation in the Outbreak Control Team, and Jane Sellwood and Jane Shore of the HPA Environmental Virology Unit (Reading) for analysis of food samples.

The study was conducted as part of an outbreak investigation and as a result all authors were funded by the organizations to which they are affiliated.

*Conflict of interest*: No conflict of interest to declare.

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